Jl S. Afr. Bot. 45 (3): 279–293 (1979)

PHENOLOGY OF THE VEGETATION IN THE HESTER MALAN NATURE RESERVE IN THE NAMAQUALAND BROKEN VELD:

1. GENERAL OBSERVATIONS

MARGARETHA W. VAN ROOYEN*, G. K. THERON AND N. GROBBELAAR
(Department of Botany, University of Pretoria)

ABSTRACT

Phenological observations were made on selected representatives of five different life form groups occurring in the Hester Malan Nature Reserve in the Namaqualand Broken Veld (Cape Province, South Africa). Phenologically the year can be subdivided into four fairly well-defined periods, *viz*. a mild, relatively moist autumn; a cold, moist winter; a mild, relatively moist spring and a hot, dry summer. Each period is characterized by certain phenological processes.

UITTREKSEL

'N FENOLOGIESE STUDIE VAN DIE PLANTEGROEI VAN DIE NAMAKWALANDSE GEBROKE VELD:

1. ALGEMENE WAARNEMINGS

Fenologiese gegewens van enkele verteenwoordigers van vyf verskillende lewensvormgroepe in die Hester Malan-natuurreservaat in die Namakwalandse Gebroke Veld (Kaapprovinsie, Suid-Afrika) word weergegee. Fenologies kan die jaar in vier redelik duidelik onderskeibare periodes verdeel word, naamlik: 'n matige, relatief vogtige herfs; 'n koue, vogtige winter; 'n matige, relatief vogtige lente en 'n warm, droë somer. Elke periode word deur sy besondere fenologiese aktiwiteite gekenmerk.

INTRODUCTION

The profound seasonal differences in the appearance of the Namaqualand vegetation suggest that the phenology of this vegetation type should be extremely interesting. Nevertheless, no phenological work on this area seems to have been done and this report is an attempt to rectify the matter to some extent. The investigation was carried out in the Hester Malan Nature Reserve and although most of the information presented in this paper was collected during 1974, some of the statements are based on observations that were made during periodic visits to the region over a period from 1973 to 1977.

The Hester Malan Nature Reserve is situated approximately 12 km east of Springbok between E 17° 57′ and E 18° 02′ and S 29° 34′ and S 29° 41′ and has an area of 4 479,63 ha. The reserve lies at the northern end of the Kamiesberg Range which is a region with a very broken topography. The elevation of the

---

*Based on an M.Sc. thesis, University of Pretoria.

Accepted for publication 20th September, 1978.

reserve varies from 884 m to 1 346 m above sea level. Geologically the area belongs to the Namaqualand Granite-Gneiss Massif (Martin, 1965) which was formed about 1 050 million years ago. Rock types on the reserve are mainly granitic gneiss and gneiss. Despite local variations, the soil is generally poorly developed and shallow with little horizontal differentiation. Along water courses, colluvial-alluvial strips occur in which the soil is impregnated with soluble salts, while the valleys and plains are covered with aeolean sand (Van der Merwe, 1940).

According to the classification of climatic regions used by the South African Weather Bureau, Namaqualand should be regarded as a desert or poor steppe (Schulze, 1965) and according to the Köppen index, the reserve borders on the BWhs and BWks climatic regions (Schulze, 1947). The region is characterized by an unpredictable annual rainfall and temperatures which show extensive daily and seasonal fluctuations. The aridity of the climate is obvious from the Walter and Lieth (1960) climatic diagram (Figure 1) in which the rainfall curve never rises above the temperature curve.

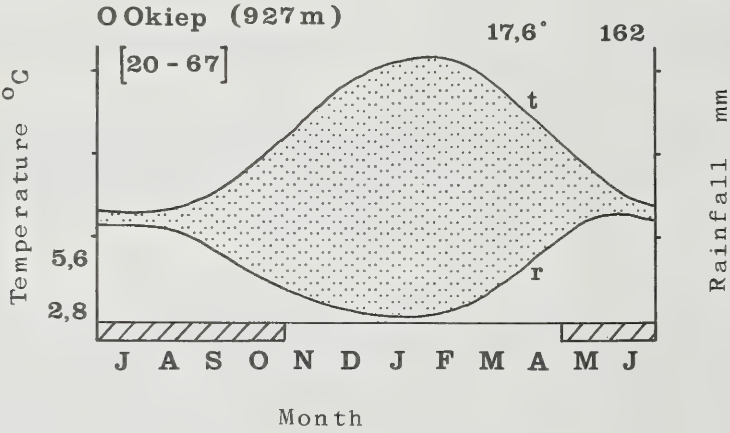

FIG. 1.
Climatic diagram for O'Okiep (Walter and Lieth, 1960).

Values for the mean monthly and annual rainfall for O'Okiep and Springbok (Weather Bureau, 1965) as well as the 1974 values for the Hester Malan Nature Reserve, O'Okiep and Springbok are provided in Table 1. The rainfall for the region is very erratic and varies considerably from year to year. Most of the annual rain falls during the four months from May to August. During 1974, however, nearly 50% of the annual rainfall of the reserve fell during January, February and March. The exceptionally high value for March of the reserve was due to a local cloud burst. Although April, May, July and September usually experience a relatively high rainfall, according to long-term data, they were fairly dry months during 1974. In June and August, however, the reserve received a fair amount of rain. Consequently the 1974 growing season started very early in March. This was followed by a relatively dry period during April and May whereupon June received a ''normal'' amount of rain. From the middle of June dry conditions once more prevailed until the August rains. Good rains towards the end of August extended the 1974 growing season into September.

TABLE 1.

Mean monthly and annual rainfall values for O'Okiep and Springbok (Weather Bureau, 1965) as well as the monthly and annual values for 1974 for the Hester Malan Nature Reserve (HMNR), O'Okiep and Springbok.* The number of rainy days per month is given in brackets.

	Rainfall in mm at				
Month	O'Okiep (av. 72y.)	Springbok (av. 83y.)	HMNR 1974	O'Okiep 1974	Springbok 1974
JAN	4,2 (1)	3,9 (1)	14,5	33,6 (5)	21,5 (3)
FEB	7,8 (1)	8,5 (1)	10,0	13,6 (5)	12,5 (3)
MAR	9,9 (3)	13,1 (2)	55,5	16,1 (3)	10,0 (2)
APR	13,8 (3)	17,8 (3)	4,6	9,9 (4)	6,5 (2)
MAY	24,3 (4)	32,7 (4)	2,4	13,1 (3)	7,2 (4)
JUN	26,6 (5)	38,0 (4)	28,7	52,5 (10)	41,7 (8)
JUL	19,2 (4)	32,7 (4)	3,2	3,2 (2)	9,1 (3)
AUG	22,8 (5)	32,0 (4)	39,5	70,8 (13)	90,8 (13)
SEP	14,3 (4)	18,7 (3)	1,0	5,5 (5)	3,5 (3)
OCT	8,8 (3)	13,3 (3)	2,9	3,8 (5)	6,8 (3)
NOV	5,7 (2)	7,6 (2)	0,0	0,5 (3)	8,5 (1)
DEC	4,1 (2)	5,6 (2)	0,0	0,1 (1)	0,0 (0)
YEAR	161,5 (38)	223,9 (34)	162,3	231,7 (59)	218,1 (45)

*Unpublished data obtained from the Department of Transport, Forum Building, Struben Street, Pretoria 0002.

The mean weekly percentage relative humidity of the atmosphere at 08h00 and 14h00 for the reserve for the period April to November 1974 is presented in Figure 2. The annual cycle of the relative humidity is of the continental type with the maximum in winter and the minimum in summer.

The weekly average of the daily maximum and minimum temperatures as well as the rainfall for the study site for the period April to November 1974 are presented in Figure 3. Attention is drawn to the fact that the rainy season and the coldest period of the year coincide. During this period it will probably be the low temperatures rather than a water shortage that will limit plant growth. Frost commonly occurs during the winter months but no frost injury to the plants was observed.

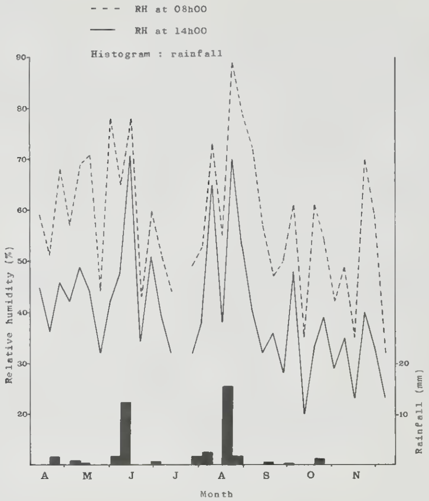

FIG. 2.
Mean weekly percentage relative humidity of the atmosphere at 08h00 and 14h00, as well as the weekly rainfall of the Hester Malan Nature Reserve from April to November 1974.

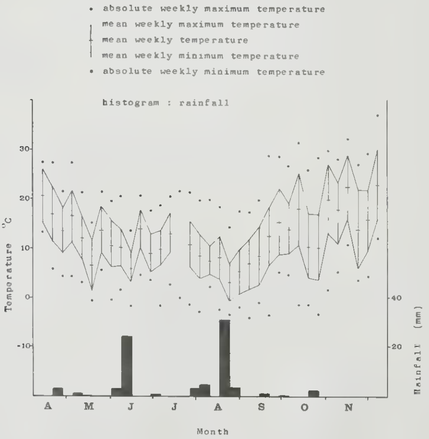

FIG. 3.
Absolute and mean weekly air temperatures and rainfall of the Hester Malan Nature Reserve from April to November 1974.

According to Acocks (1975) the study area lies within the Namaqualand Broken Veld and borders on the False Succulent Karoo. Physiognomically the vegetation has a decided chamaephytic character (Rösch, 1977). Many of the dwarf shrubs exhibit xeromorphic characteristics by being deciduous, microphyllous, aphyllous and/or succulent. A large percentage of the species are therophytes that are especially conspicuous during the spring of a good rainy season.

METHODS

Phenological data were collected for 116 species at fortnightly intervals from April to November during 1974. Instead of repeatedly investigating specific individuals of the species, the general condition of plants scattered throughout the reserve was noted. At any observation date a species was regarded to be in a particular phenological stage only if at least 10% of the plants of the species were in that phenological stage.

The following developmental stages were recorded:

vegetative growth: production of leaves and/or existing leaves not senescent;
production of floral buds: unopened flower buds present on plants;
flowering: flowers at anthesis on plants;
fruit development: developing fruit present on plants; and
mature fruit: mature fruit present on plants.

The species investigated were grouped into five different life-form categories according to the revision of the Raunkiaer plant life forms by Müller-Dombois and Ellenberg (1974).

A principal components analysis (Seal, 1968) was carried out on the phenological data of the 116 species that were investigated.

RESULTS AND DISCUSSION

Among the investigated species 44 were therophytes, 24 geophytes, 8 hemicryptophytes (H), 29 chamaephytes (Ch) and 7 were phanerophytes (P). The phenological diagrams of the therophytes, geophytes and phanerophytes, chamaephytes and hemicryptophytes are presented in Figures 4, 5 and 6 respectively. Within each figure the species are arranged according to the time of onset of flowering.

General observations over a number of years reveal that although the various phenological stages regularly occur in the same sequence, the exact times of the various stages vary somewhat from year to year.

In Namaqualand a year can be divided into four fairly well defined phenological periods, *viz.*:

a. a mild, relatively moist autumn, during March, April and early May;
b. a cold, moist winter during late May, June and July;

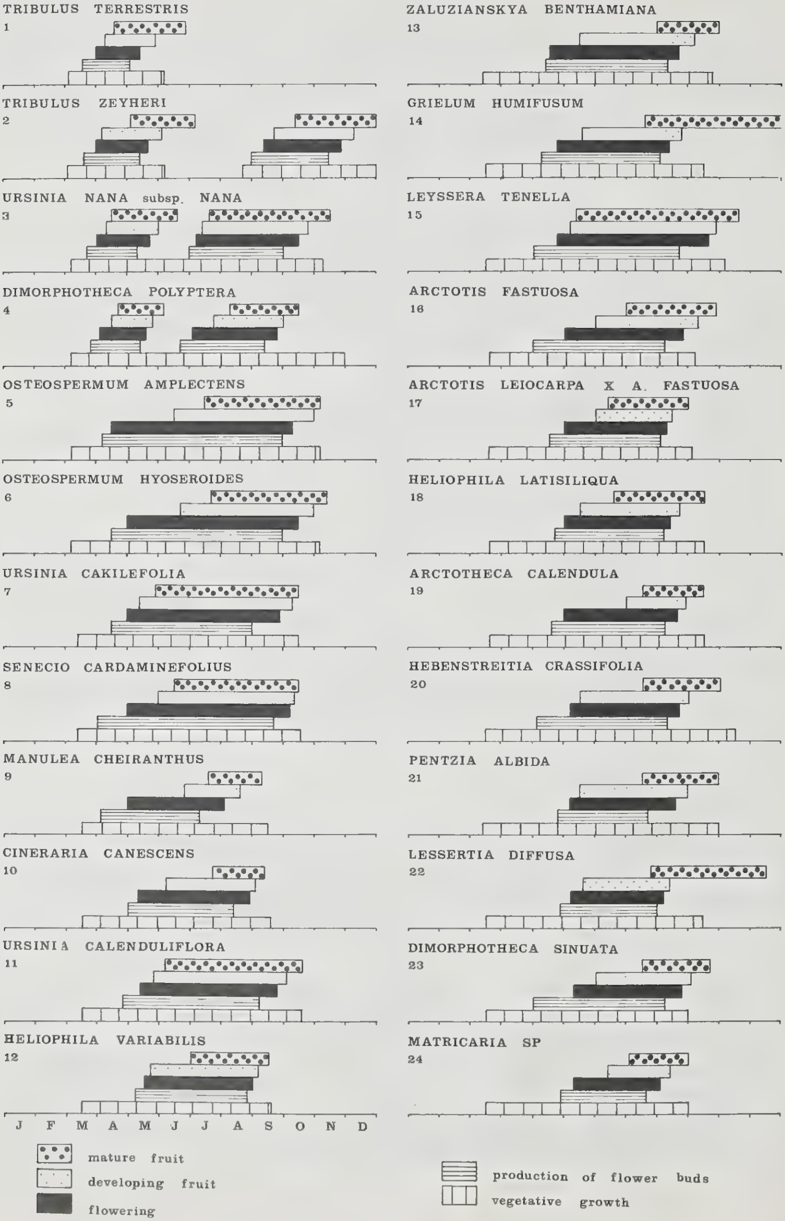

FIG. 4.

Phenodiagrams of selected therophytes in the Hester Malan Nature Reserve.

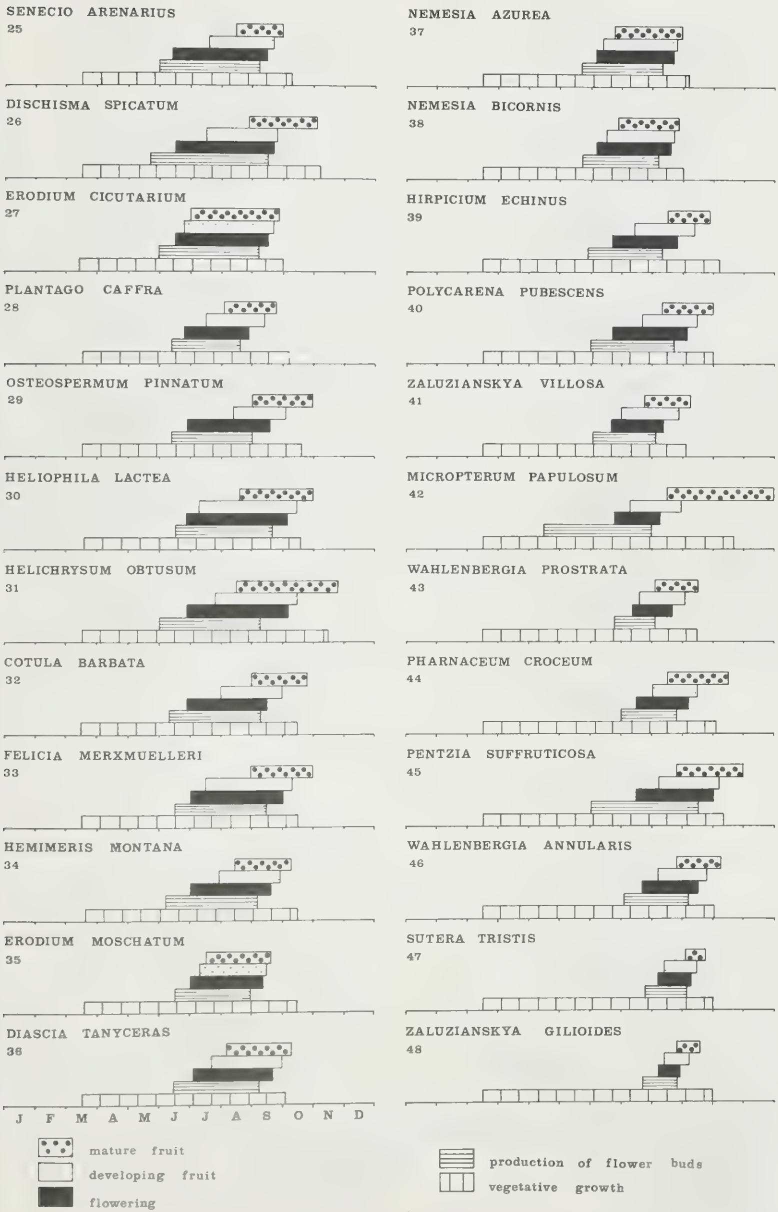

FIG. 4.

Phenodiagrams of selected therophytes in the Hester Malan Nature Reserve.

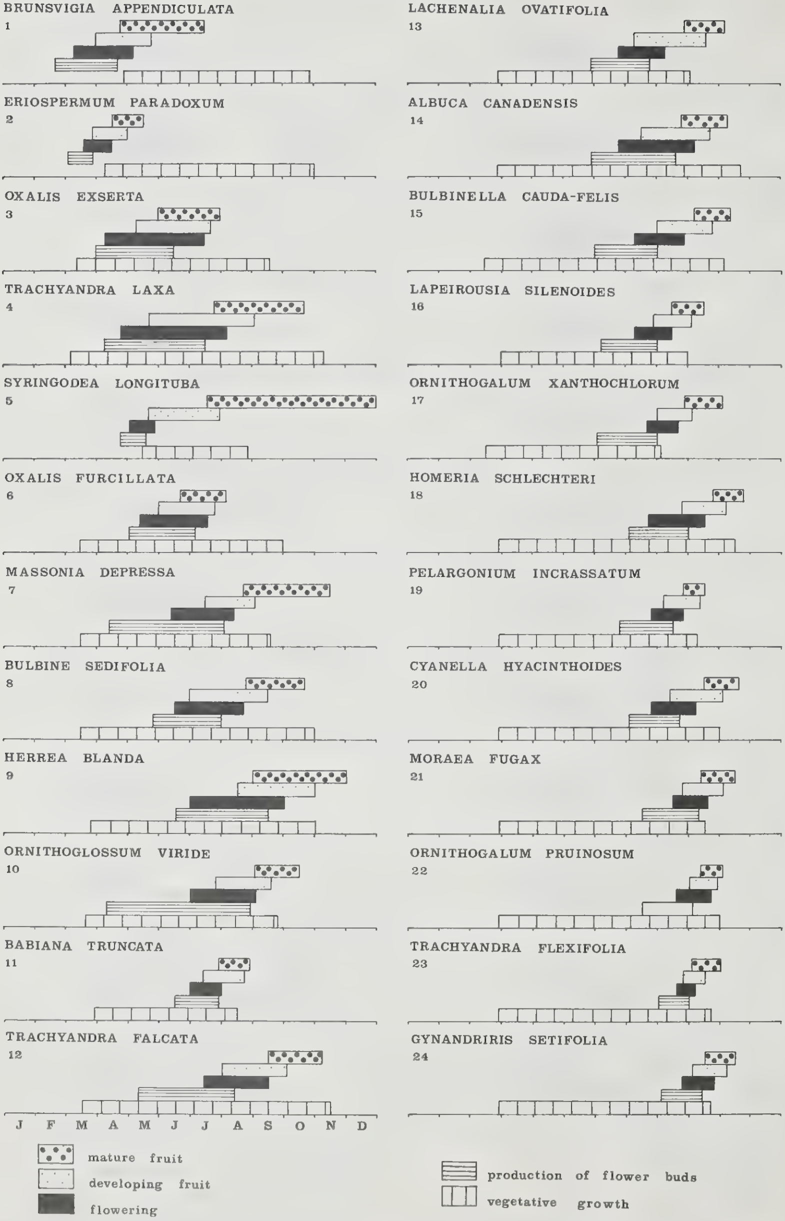

FIG. 5.
Phenodiagrams of selected geophytes in the Hester Malan Nature Reserve.

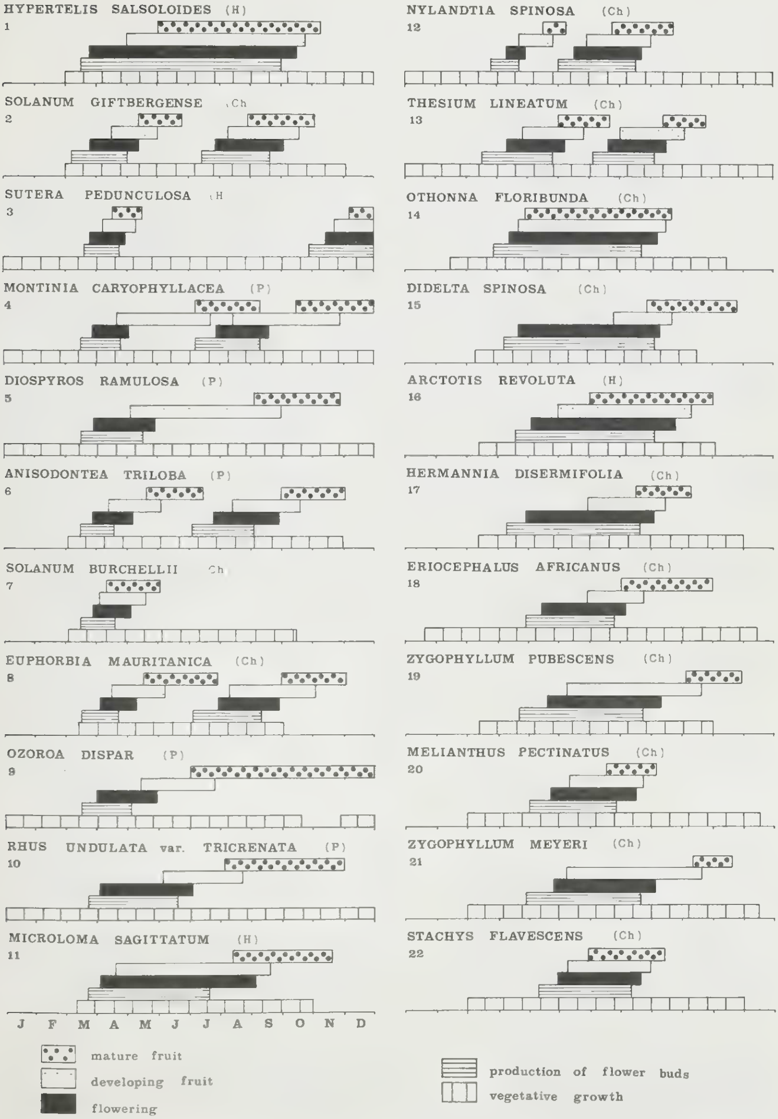

FIG. 6.

Phenodiagrams of selected phanerophytes (P), chamaephytes (Ch) and hemicryptophytes (H) in the Hester Malan Nature Reserve.

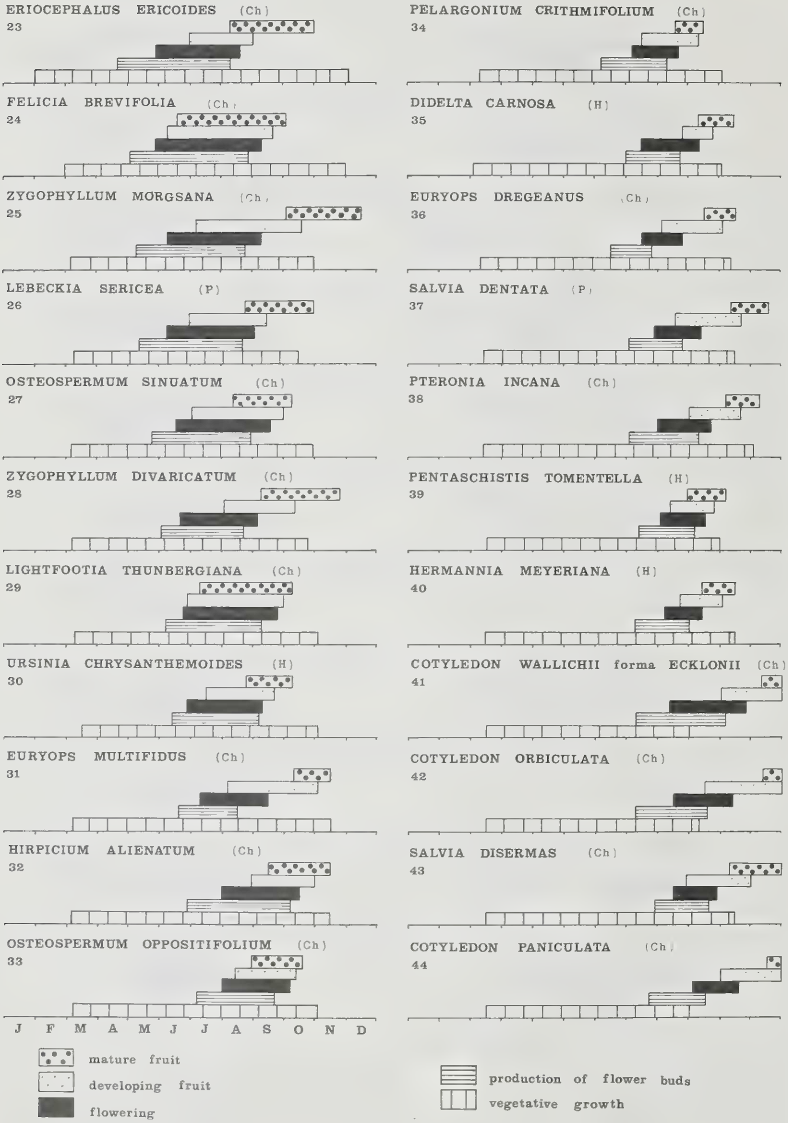

FIG. 6.
Phenodiagrams of selected phanerophytes (P), chamaephytes (Ch) and hemicryptophytes (H) in the Hester Malan Nature Reserve.

c. a mild, relatively moist spring during August, September and early October; and
d. a hot, dry summer from late in October to the end of February.

The growing season generally starts in autumn or late summer following good rains and a drop in the prevailing temperatures. Between 10 and 13 March 1974 the reserve received 55,5 mm of rain. When the observations were commenced in April, most of the perennial species were growing actively and many of the deciduous species were sprouting. It is possible, however, that some of the deciduous species had already started to sprout after the rains in February. Only a few perennial species, such as *Solanum* species (Ch), *Montinia caryophyllacea* (P), *Diospyros ramulosa* (P), *Ozoroa dispar* (P) and *Rhus undulata* var. *tricrenata* (P) flower in autumn (Figure 6). Seed germination, especially of therophytes, takes place mainly in autumn. Few therophyte species flower in autumn and complete their life cycle before the onset of winter. *Tribulus* species (Figure 4) flower in autumn and complete their life cycle before the onset of winter. These plants, however, originate from seeds which germinate in summer. A few geophytes such as *Brunsvigia appendiculata* and *Eriospermum paradoxum* (Figure 5) also flower in autumn and subsequently produce vegetative leaves.

As the temperature drops further during the winter months, the growth rate of the plants decreases to a very low level, despite the fact that this period is usually the wettest part of the year. For instance, during 1974 the 28,7 mm of rain in June had little obvious effect on the growth rate of the plants. The flowering of many chamaephytic species, such as *Didelta spinosa*, *Hermannia disermifolia* and *Eriocephalus* species (Figure 6) begins in winter. Most therophyte species will not attain their peak flowering stage during winter. Under unfavourable growing conditions the therophytes may however produce a small number of flowers during winter, as happened in 1974 when the early winter was relatively dry and the plants were quite depauperate.

Flowering occurs mainly in spring, after the temperature has risen, but before drought conditions set in. In 1974, hardly any rain fell from mid-June to mid-August and by the end of this long dry period it seemed as though most of the therophytes were on the verge of dying. A good rain at this stage stimulated the plants into active growth and flowering; and by early September the flowering of the therophytes had reached its peak. Many of the perennial shrubs, such as *Osteospermum sinuatum* (Ch) (Figure 6) which had started to flower in winter, produced a large number of additional flowers at this stage, thus covering the entire plants.

Phenologically, spring can possibly be subdivided into a prevernal (early spring) and vernal (late spring) aspect. The well-known flowering season of Namaqualand constitutes the prevernal aspect when a large percentage of the therophyte species, such as *Ursinia* species, *Osteospermum* species, *Heliophila* species, *Arctotis* species, *Arctotheca calendula*, *Pentzia* species, *Dimorphotheca* species, *Cotula* species, *Nemesia* species and *Gazania* species (Figure 4) are in full bloom. Perennial species of *Osteospermum* (Ch), *Felicia* (Ch) and *Lebeckia* (P) are also quite conspicuous during this period (Figure 6). During late spring (the vernal aspect), it is mainly geophytes (Figure 5), such as *Albuca* species, *Ornithogalum* species, *Homeria* species, *Moraea* species and *Gynandriris* species as well as a number of the Mesembryanthemaceae, such as *Drosanthemum* species, *Leipoldtia* species and *Ruschia* species that reach their flowering peak. Shrubs which flower late in spring are, amongst others, *Hirpicium alienatum* (Ch), *Berkheya* species (Ch), and *Salvia dentata* (P) (Figure 6). A few shrubby species such as *Montinia caryophyllacea* (P) and *Anisodontea triloba* (P) flowered during both the autumn and spring of 1974. Other important phenological processes which take place during spring are the ripening and dispersal of fruit and seed, especially of the therophyte species.

Phenologically the summer begins when the deciduous species start shedding their leaves. Very few species flower during this time of the year and those that do, such as *Cotyledon* species and *Gethyllis* species, have by then usually completed their vegetative growth for the season. Many fruits and seeds, especially of the perennial species ripen during summer. A few species, such as *Othonna furcata*, flower towards the end of summer before any vegetative leaves have been produced.

Active plant growth is therefore limited mainly to autumn and spring, when both temperature and moisture conditions are favourable for plant growth. During winter the low temperatures possibly inhibit growth, whereas the combined effects of high temperatures and water deficiency during summer possibly preclude plant growth. This annual growth pattern is very similar to that which is found in regions with a Mediterranean climate (Mooney & Dunn, 1970; Mooney, Parsons & Kummerow, 1974).

The phenological spectrum of the species comprising a community or veld type often provides a good insight into the relations between the different life form groups. In the case of the Hester Malan Nature Reserve it was found that the annual growing season of the therophytes comes to an end first. Thereafter most of the shrubs and geophytes become dormant until finally the succulents cease to grow. This statement is supported by a principal components analysis of the phenological data collected on the reserve in 1974. Results (Figure 7) show that the phenological patterns of the therophytes, perennial shrubs (phanerophytes, chamaephytes and hemicryptophytes) and geophytes differ.

The flowering periods of plant species can be used as a basis for speculating about their affinities to other vegetation types. Species that flower in winter can possibly be regarded as having affinities to the Cape Flora, which also lies in a winter rainfall region. On the other hand, species that flower in summer probably have a northern and/or eastern origin.

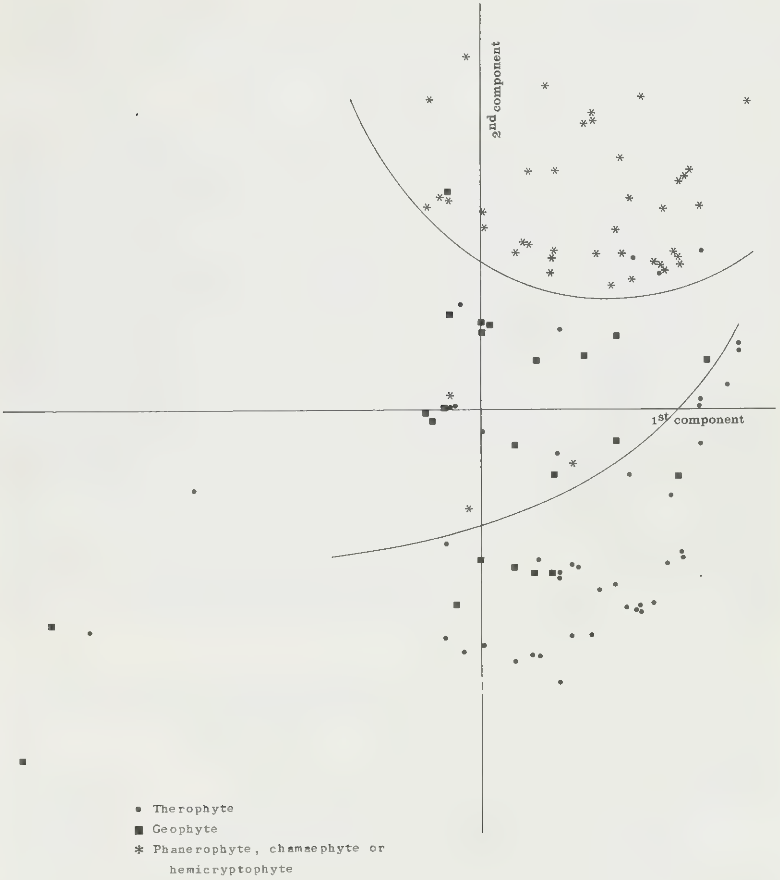

FIG. 7.
A scatter diagram of the life forms as determined by the first two components of a principal components analysis of the phenological data of selected species in the Hester Malan Nature Reserve.

The control of the phenological development of plants is probably very complex. In some cases temperature is thought to be of overriding importance, but in other cases moisture, day length and temperature are probably equally important and interact strongly in regulating the development of plants (Ratcliffe, 1961; Zohary, 1962; Ackerman and Bamberg, 1974; Taylor, 1974; Davies, 1976). Zohary (1962) claims that the flowering season of many species is not determined by the environment in which the plants are currently growing, but is controlled by endogenous factors, such as a phenological rhythm which was induced by the environment from which the species migrated.

SUMMARY

The study was conducted in the Hester Malan Nature Reserve which is situated in the Namaqualand Broken Veld. The climate of the study area is best described as a hot and dry desert climate characterized by sparse and erratic rainfall and considerable daily and seasonal temperature fluctuations. The phenology of the species occurring in this region is closely related to the climate.

Even though some of the perennial species had already started to sprout by the end of summer, the beginning of the rains in autum was regarded as the start of the growing season. Germination of therophyte seeds occurs mainly after these autumn rains. Growth during the winter months is slow, despite the adequate available moisture, possibly as a result of low temperatures. A number of perennial plant species normally flower during winter but many therophyte species will also produce some flowers in winter if conditions are unfavourable for vegetative growth. The main flowering period of most of the annual as well as perennial species is in spring and by the end of this season there are a large number of species which disperse their diaspores. The summer phenological aspect begins when the perennial plant species lose their leaves and become dormant. Very few plant species flower during summer and the most noteworthy phenological phenomenon during this period is diaspore dispersal.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support received from the Council for Scientific and Industrial Research during the course of the field work.

REFERENCES

ACKERMAN, T. S. and BAMBERG, S. A., 1974. Phenological studies in the Mojave Desert at Rock Valley. In: Lieth, H. (ed.), *Ecological studies*. 8. *Phenology and seasonality modeling*. pp. 215–226. London: Chapman & Hall, Ltd.

ACOCKS, J. P. H., 1975. Veld types of South Africa. 2nd edition. *Mem. bot. Surv. S. Afr.* **40:** 1–128.

DAVIES, S. J. J. F., 1976. Studies of the flowering season and fruit production of some arid zone shrubs and trees in Western Australia. *J. Ecol.* **64:** 665–687.

JACKSON, M. T., 1966. Effects of microclimate on spring flowering phenology. *Ecology* **47:** 407–415.

MARTIN, H., 1965. *The Precambrian geology of South West Africa and Namaqualand*. Cape Town: The Precambrian Research Unit.

MOONEY, H. A. and DUNN, E. L., 1970. Convergent evolution of Mediterranean climate evergreen sclerophyll shrubs. *Evolution Lancaster, Pa.* **24:** 292–303.

MOONEY, H. A., PARSONS, D. J. and KUMMEROW, J., 1974. Plant development in Mediterranean climates. In: Lieth, H. (ed.), *Ecological Studies*. 8. *Phenology and seasonality modeling*. pp. 255–267. London: Chapman & Hall, Ltd.

Müller-Dombois, D. and Ellenberg, H., 1974. *Aims and methods of vegetation ecology*. New York: John Wiley & Sons.

Ratcliffe, D., 1961. Adaptation to habitat in a group of annual plants. *J. Ecol.* **49:** 187–203.

Rösch, Margaretha W., 1977. *Enkele plantekologiese aspekte van die Hester Malan-natuurreservaat*. M.Sc. thesis. Pretoria: University of Pretoria.

Schulze, B. R., 1947. The climates of South Africa according to the classifications of Köppen and Thornthwaite. *S. Afr. geogr. J.* **29:** 32–42.

Schulze, B. R., 1965. *Klimaat van Suid-Afrika*. Deel 8. *Algemene oorsig*. W.B. 28. Pretoria: Staatsdrukker.

Seal, Hilary, 1968. *Multivariate statistical analysis for biologists*. London: Methuen.

Taylor, F. G., 1974. Phenodynamics of production in a mesic deciduous forest. In: Lieth, H. (ed.), *Ecological studies*. 8. *Phenology and seasonality modeling*. pp. 237–254. London: Chapman and Hall, Ltd.

Van der Merwe, C. R., 1940. *Soil groups and subgroups of South Africa*. Pretoria: Government Printer.

Walter, H. and Lieth, H., 1960. *Klimadiagramm-Weltatlas*. Jena: Fischer.

Weather Bureau, 1965. *Climate of South Africa*. Part 9. *Average monthly rainfall up to the end of 1960*. W.B. 29. Pretoria: Government Printer.

Zohary, M., 1962. *Plant life of Palestine, Israel and Jordan*. New York: The Ronald Press Co.